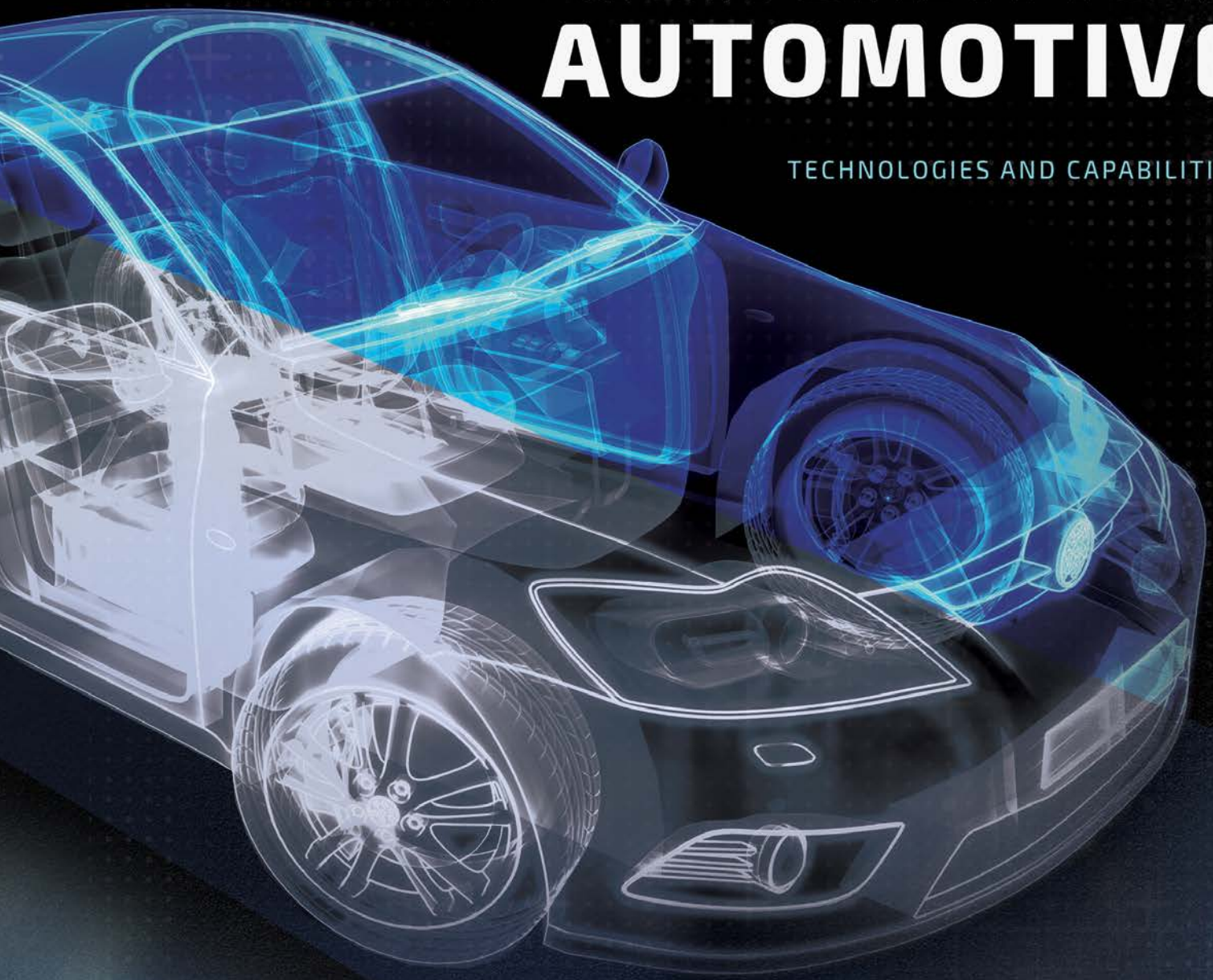
Sandia National Laboratories

NEXT-GENERATION AUTOMOTIVE

TECHNOLOGIES AND CAPABILITIES



SANDIA'S INNOVATION MARKETPLACE

MARCH 2020

WELCOME TO SANDIA NATIONAL LABORATORIES'

INTELLECTUAL PROPERTY MAGAZINE

Innovation Marketplace is a magazine that highlights Sandia National Laboratories' exceptional research capabilities and intellectual property, including patents, copyrighted software, trademarks, and mask works. Listings within should not be construed as an offer to license technology. All licenses are subject to negotiation and availability of the intellectual property. This publication is intended for indications of interest only.

Why Work with Sandia?

Leverage World-Class Technology and Research

For 70 years, Sandia has delivered essential science and technology to resolve the nation's most challenging security issues. A strong science, technology, and engineering foundation enables Sandia's mission through a capable research staff working at the forefront of innovation, collaborative research with universities and companies, and discretionary research projects with significant potential impact.

The Best and Brightest

In keeping with our vision to be the nation's premier science and engineering laboratory for national security and technology innovation, we recruit the best and the brightest, equip them with world-class research tools and facilities, and provide opportunities to collaborate with technical experts from many different scientific disciplines. The excitement and importance of our work, an exemplary work environment, partnerships with academia, industry, and government, and our record of historic contributions help us attract exceptional staff. Our employees are recognized by their professional peers for their outstanding contributions.

Exceptional service in the national interest

CONTENTS

AUTOMOTIVE INNOVATION AT SANDIA

From freight transport to the daily commute, transportation plays a crucial role in our nation's economy and overall security. Sandia conducts fundamental research to understand the science and engineering required for transportation that not only meets sustainability targets but also advances the development of next-generation technologies.

Sandia Partnership

1960s: Early rolamite sensors, invented for the weapons program, were licensed and used for the deployment of automobile airbags until they were replaced in the mid-1990s by newer technology.

1970s: Initial partnership established with General Motors, beginning with the Direct Injection Stratified Charge (DISC).

1980: The Combustion Research Facility (CRF) was established at Sandia's Livermore, California site to foster collaborations with industry and academia.

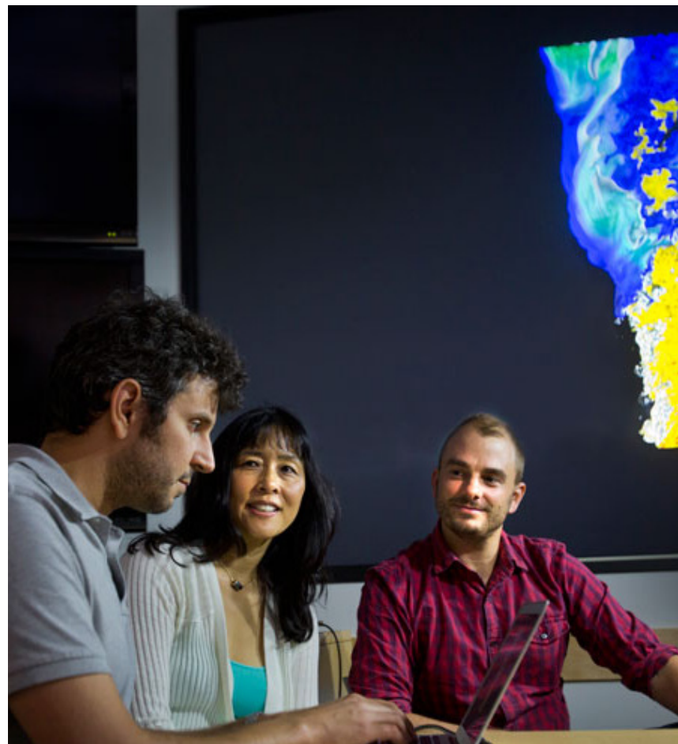
1992: Partnership with Goodyear Tire & Rubber Company established, resulting in the Assurance TripleTred Tire, Consumer Reports' most recommended all-season tire. Sandia's advanced computational mechanics software enabled the production of innovative tires in record times.

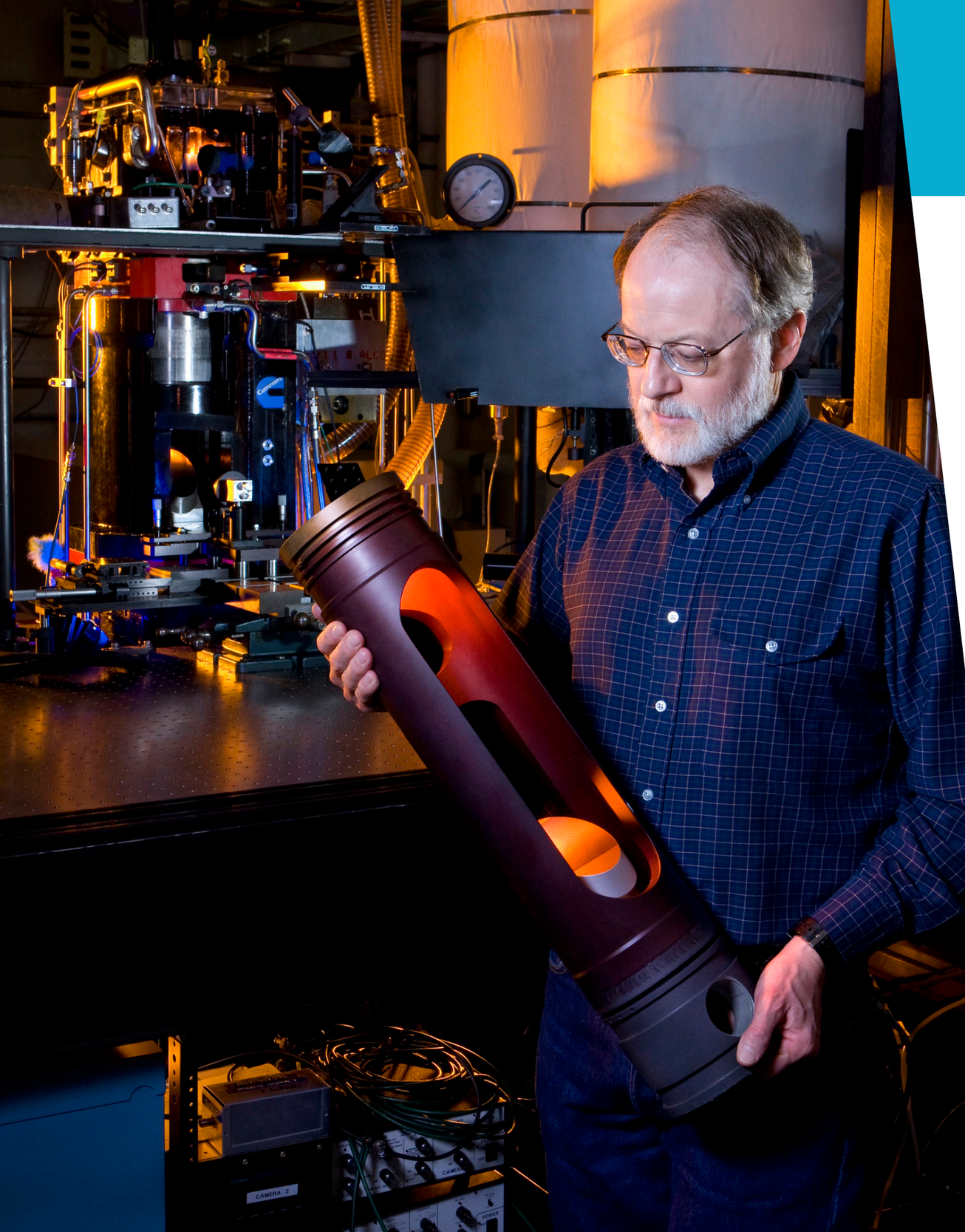
1997: Sandia licensed integrated MEMS sensors to Analog Devices, an industry leader in the manufacture of airbag sensors.

2007: Partnership with Cummins established, resulting in the world's first diesel engine designed entirely computationally.

2014: TriLumina, a New Mexico-based semiconductor laser technology startup, took part in the New Mexico Small Business Assistance (NMSBA) Program to successfully optimize existing technologies that support Light Detection and Ranging (LiDAR) for Advanced Driver Assistance Systems.

These efforts are grounded in many decades of research and collaboration with academic, industry, and government partners.





INTERNAL COMBUSTION ENGINES AND FUELS

Simultaneous innovation in fuels and engines can advance the delivery of technologies for better fuel economy and reduced emissions. Sandia works with diverse partners to develop the science basis for the next generation of engines and fuels.

Combustion Research Facility

Since 1980, the Combustion Research Facility (CRF) has served as a national and international leader in combustion science and technology. Located at Sandia's Livermore, California site, the CRF conducts basic and applied research with academic, industry, and government entities aimed at improving our nation's clean and efficient use of combustion processes. CRF research programs are supported primarily by the U.S. Department of Energy (DOE) Office of Science Basic Energy Sciences Program and Office of Energy Efficiency and Renewable Energy (EERE) Vehicle Technologies Office (VTO).

Engine Combustion Network

To generate the combustion and emissions knowledge base required by U.S. industry, Sandia leads the Engine Combustion Network (ECN), a voluntary international collaborative research program involving 40 active industry, government, and university partners. The ECN provides a forum for experimental and computation researchers to overcome barriers to the development of next-generation, high-efficiency clean engines.

Spray Combustion Consortium

Formed in 2015, the Spray Combustion Consortium (SCC) is an industry-funded research program aimed at understanding the fundamental processes that govern fuel sprays and their combustion properties. Intended for industry, software vendors, and national laboratories, the consortium provides a direct path from fundamental research to validated engineering models used in combustion engine design.

"Breaking the soot-NOx trade-off is the holy grail of diesel engine development."

- Paul Miles, Engine Research Program Manager

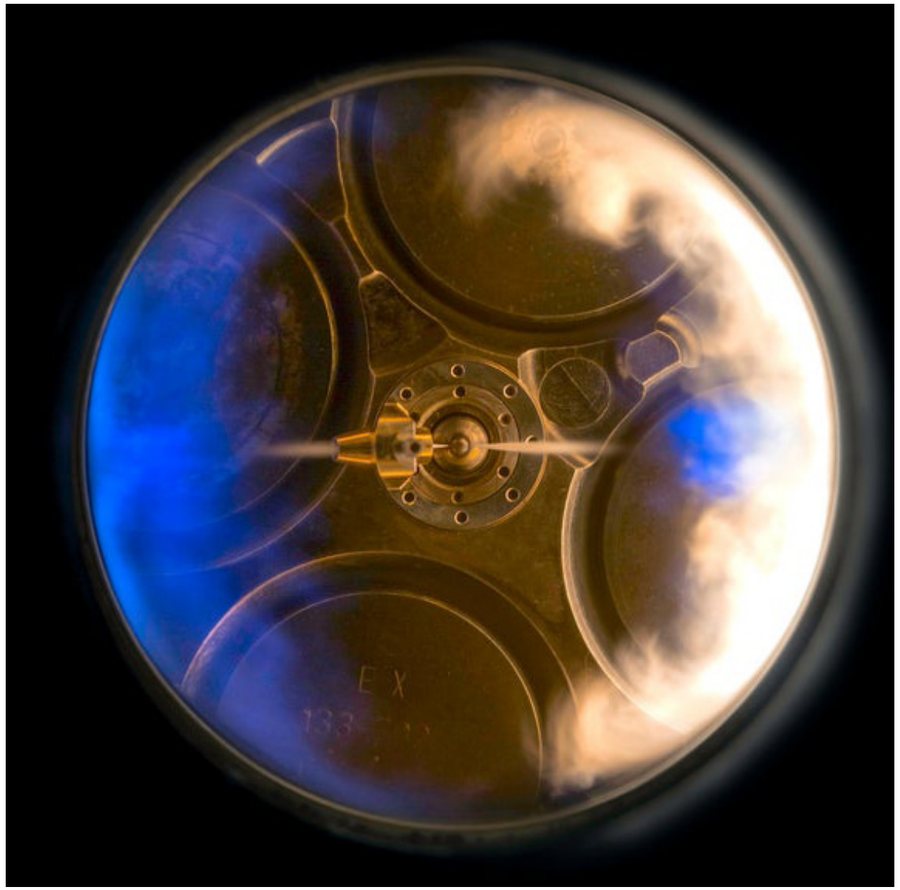
ADVANTAGES

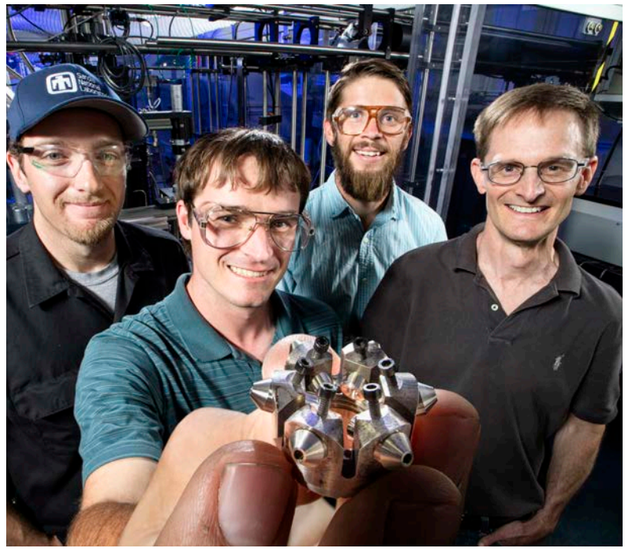
- Decreases soot and NOx emissions at the point of combustion
- Reduces the need for exhaust aftertreatment
- Reduces overall engine system costs
- Fully compatible with conventional diesel fuel and synergistic with oxygenated renewables
- Affordable retrofit option for existing diesel engines

APPLICATIONS

- Diesel engines
- Spark ignition engines
- Gas turbine engines
- Industrial boilers
- Wellhead / refinery flaring

R&D 100 AWARD 2019: GREEN TECHNOLOGY





DUCTED FUEL INJECTION

Dramatically reduces emissions while maintaining combustion efficiency in new and existing diesel engines.

A simple, mechanical device conceived and tested by researchers at Sandia's Combustion Research Facility (CRF) has the potential to enable cost-effective and simultaneous reductions of soot and nitrogen oxide emissions of 50 to >90%, encourage the use of renewable fuels, and maintain or improve engine performance. Typical diesel engines produce soot due to fuel-rich combustion conditions. Filters and catalytic converters are currently used to reduce soot and harmful emissions, but these systems are expensive, large, complex, and penalize engine efficiency.

Ducted Fuel Injection (DFI) is a mechanical solution that reduces soot at the point of combustion, thereby reducing the need for after-treatment devices and associated costs. By directing each fuel spray from the fuel injector through a small duct located within the combustion chamber, an optimized mix of fuel and oxygen is released into the combustion chamber — eliminating soot that results from unevenly mixed, fuel-rich combustion. With soot no longer a problem, exhaust-gas recirculation can be used for low-cost mitigation of NOx emissions.

This research was conducted as part of the Co-Optimization of Fuels & Engines (Co-Optima) Initiative.

US Patents 9,909,549; 10,138,855; 10,161,626

Technology Readiness Level: 3

ELECTRIFICATION, BATTERIES, AND POWER ELECTRONICS

As electric vehicles (EVs) become more pervasive, so does demand for battery chemistries and cell technologies to reduce costs, improve driving range, and decrease charge time. Sandia is working to advance research in areas of electrification, batteries, and power electronics.

Battery Abuse Testing Laboratory

Sandia's Battery Abuse Testing Laboratory (BATLab) is an internationally recognized leader in energy storage system safety research. It is committed to serving the energy storage community and the national interest with cutting-edge research programs, the highest quality testing results, and leadership in battery safety and reliability. BATLab houses an extensive calorimetry laboratory, unique hardened test cells for destructive testing in a safe operational environment, battery prototyping capabilities, and access to Sandia's broader testing capabilities and facilities.

Electric Drive Technologies Consortium

This effort is part of a multi-lab consortium that leverages U.S. research expertise and facilities at national labs and universities to significantly advance electric drive power density and reliability, while simultaneously reducing cost. The power electronics focus is dedicated to developing and evaluating optimized materials and components including wide-bandgap (WBG) semiconductors as well as dielectric and magnetic materials.

Joint Center for Energy Storage Research

Sandia was a founding member of the Joint Center for Energy Storage Research (JCESR), one of the U.S. Department of Energy's (DOE) Energy Innovation Hubs. This major partnership integrates researchers from many disciplines to overcome critical scientific and technical barriers and create new breakthrough energy storage technology.

LOW INDUCTANCE DC POWER BUS

A low-inductance DC power bus for high-frequency, high-temperature operation in electric drive systems and next-generation power electronics.

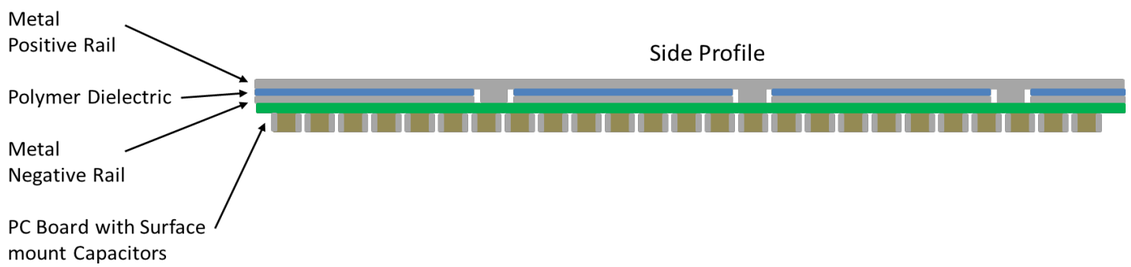
Applications in civilian and defense sectors are realizing improved power density and efficiency in power converters that utilize silicon carbide (SiC) and/or gallium nitride (GaN) switches. However, as semiconductor switches become capable of greater hold-off voltage, higher switching frequency, and higher junction temperature, limits on converter performance will depend on the balance of the system: device packaging, filter components, and thermal management as examples.

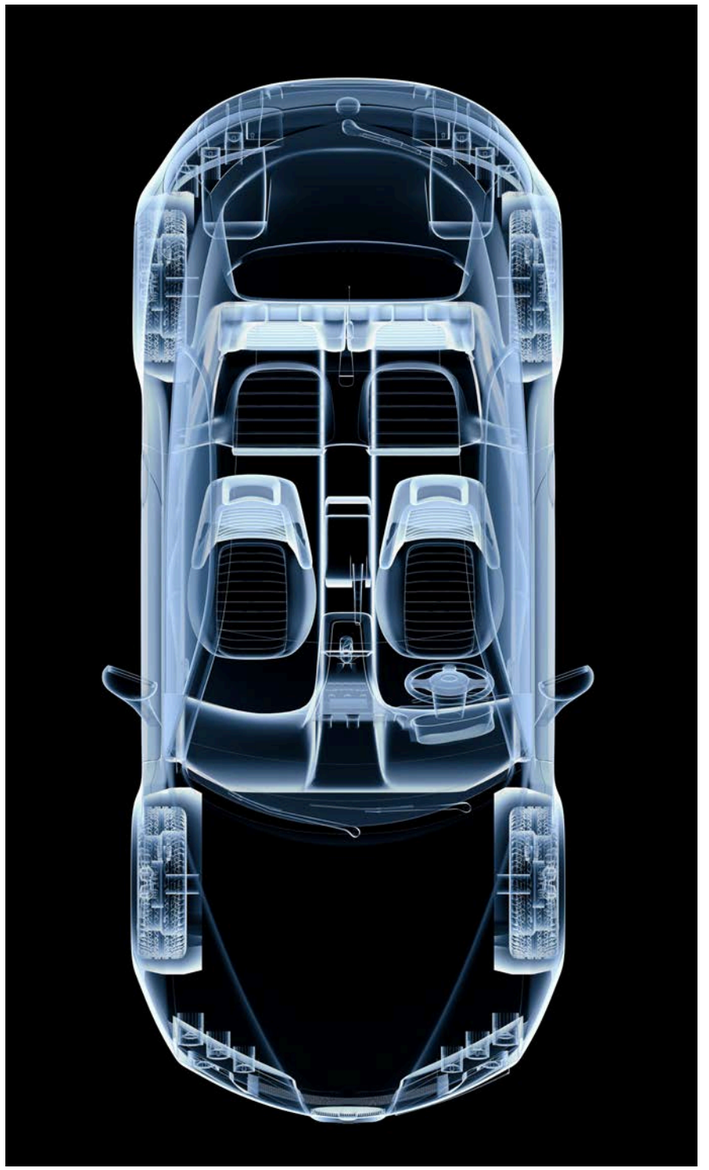
To fully realize the benefits of wide bandgap (WBG) devices in an inverter, DC link capacitors must support high frequency switching, be co-located with the switches to mitigate parasitic inductance, and be capable of higher temperature operation (due to switch proximity). To this end, Sandia researchers have developed a **Low-Inductance DC Power Bus** for high frequency, high temperature operation in electric drive systems and next-generation power electronics.

The **Low-Inductance DC Power Bus** demonstrates substantial reductions in parasitic inductance over conventional DC link systems by using a printed circuit board to maximize planar capacitance and carefully controlled capacitor placement. Utilizing ceramic rather than standard electrolytic or film capacitors helps to achieve higher operating temperatures and improved thermal management. Parallel capacitor placement provides low shunt impedance to high-frequency current components and smooths current spikes created by switching operations. Beyond electric vehicle drive systems, this system may be relevant in electric drive applications where high-frequency switching and/or high temperature operations are desired.

US Patent 10,084,310

Technology Readiness Level: 3





ADVANTAGES

- Reduced parasitic inductance
- High frequency operation (>100 kHz)
- High temperature operation and improved thermal management
- Increased power density with reduced overall size
- Supports WBG devices
- May be fabricated with simple PCB assembly methods

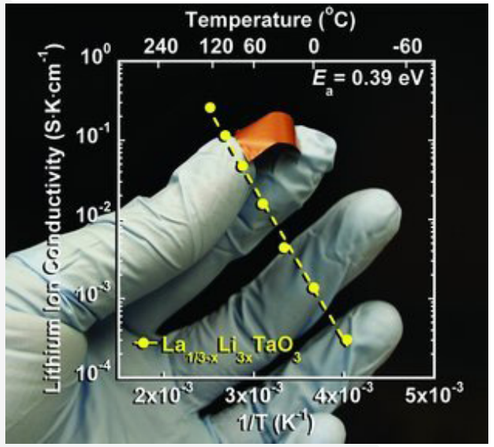
APPLICATIONS

- Electric drive systems
- Electric vehicles (EVs)
- High frequency switching
- Grid-tied power systems
- Geothermal
- Oil and gas

SOLID STATE LITHIUM BATTERY

A higher-power, solid-state thin film battery for breakthrough conductance and performance in electric vehicles.

Enhancing battery safety and durability, reducing form factor, and increasing range remains a priority for furthering the widespread enablement of electric vehicles (EVs). Solid-state batteries have garnered growing interest for their potential in these areas, yet technical limitations negatively impacting battery efficiency have hindered its commercial viability.



Sandia researchers have developed a higher-power, **Solid State Thin Film Battery** as a more durable and energy dense solution for EVs and electronics. By leveraging a lithium-stable, higher conductivity electrolyte – lanthanum lithium tantalate (Li5La3Ta2O12) – and inexpensive metal foil substrates, this technology enables a solid-state lithium battery with high power in a very low form factor. Researchers have demonstrated 15 to 1000x improved conductance, enhanced power density, and wider temperature range over industry standard LiPON thin films. The new materials and battery geometries overcome limitations such as stress-induced film fracturing to deliver compact, robust, and higher energy density batteries that could revolutionize the EV market with improved driving range, battery life, and reduced cost per kilowatt hour. A thin and flexible battery substrate also presents advantages for reel-to-reel manufacturing, flexible electronics, and applications requiring low profiles.

US Patent 8,877,388

Technology Readiness Level: 4

NANOSCALE ENABLED MICROINDUCTORS

Nanoscale enabled microinductors with reduced size, weight, power, and cost (SWaP-C) for broad-ranging electronics applications.

Scaling of magnetic passive components such as inductors and transformers has not kept pace with advances in high power semiconductor devices employing wide/ultra-wide band gap SiC, GaN, and AlN in terms of size or performance. While higher switching frequencies are enabled by these devices (100 kHz for SiC; 1 MHz or more for nitride-based devices), magnetic passive elements have not scaled accordingly due to a variety of energy loss mechanisms that increase at higher frequencies. These larger and heavier passive components limit the power density that can be achieved in power electronic systems. A new effort is needed to explore next generation mesoscale (i.e., mm size) magnetic passive components that go beyond the limits of current technology.

Sandia researchers have created a novel inductor with significantly lower losses by using a nano-scale enabled magnetic material that is nonconducting, non-hysteretic, and has a high saturation magnetization. This new device will combine this nanocomposite material with microsystems technology, both developed at Sandia. These technologies will be combined in an advanced integration scheme to reduce the effects of these loss mechanisms while enabling performance improvements afforded by scaling to smaller dimensions. This technology is expected to achieve a minimum of 10X improvement in device performance (>1 MHz, 10 μH) or a 10X reduction in device size compared to a device made with current technology.

Patent Pending

Technology Readiness Level: 2-3

ADVANTAGES

- Lower energy losses achieved using a nano-enabled magnetic core material
- 10X improvement in device performance (> 1 MHz, Q's > 100) or 10X reduction in device size compared to existing technology
- Monolithic integration possible for chip-scale power converters

APPLICATIONS

- Automotive
- Defense/security
- Microelectronics
- Integrated microinductors/ transformers

MATERIALS AND COATINGS

Lightweight vehicles travel farther on a gallon of fuel or a per-charge basis, but developing and manufacturing new and innovative materials presents complex challenges. Sandia provides deep knowledge of materials structure, properties, and performance as well as the processes to produce, transform, and analyze materials.

Center for Integrated Nanotechnologies

The Center for Integrated Nanotechnologies (CINT) is a U.S. Department of Energy (DOE) funded nanoscience research facility that provides users from around the world with access to state of the art expertise and instrumentation in a collaborative, multidisciplinary environment with a focus on nanoscience integration.

Lightweight Materials National Lab Consortium

Sandia participates in the Lightweight Materials National Lab Consortium, or LightMat. Established as part of the Energy Materials Network under the U.S. Department of Energy's (DOE) Clean Manufacturing Consortium, the mission of LightMat is to create an enduring national lab-based network that enables industry to utilize the national labs' unique capabilities related to lightweight materials.

RAPID ELECTROPULSING METHOD

FOR METALLIC ADDITIVELY MANUFACTURED (AM) PARTS

A rapid electropulsing method to reduce chemical microsegregation in metallic additively manufactured (AM) parts comparable to conventional heat-treatment in a fraction of the processing time.

Sandia researchers have developed a rapid method to reduce chemical microsegregation in metallic AM parts comparable to conventional heat-treatment techniques in a fraction of the processing time using short, high-current density electrical pulses (electropulsing). Electrical pulses were passed through 316L stainless steel and aluminum silicon magnesium (AlSiMg) parts fabricated by SLM using a Gleeble® 3500. For stainless steel parts, electropulsing significantly reduced the chemical microsegregation in the as-fabricated part after 10 pulses without significantly altering hardness. Total processing time for this material was 200 seconds, compared conventional heat treatment at 800° C for 2 hours with reduced part hardness. For aluminum, 100 pulses at a current density of 1.68 kA/mm2 were applied to the part for a total processing time of 1,000 seconds, producing three times greater ductility in the electropulsed part in the as-fabricated condition.

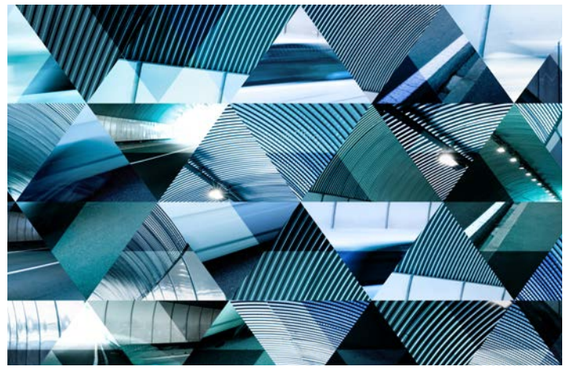
Patent Pending
Technology Readiness Level: 4

ADVANTAGES

- 10x faster processing of stainless steel SLM parts with similar results as conventional heat-treatment
- Enables target modification of a small area, rather than the entire part
- Improved efficiency and throughput

APPLICATIONS

- Automotive
- Aerospace
- Rapid prototyping
- Additive manufacturing (AM)



NANOCOMPOSITE CONFORMAL ANTI-CORROSION COATING

A high performing anti-corrosion coating to minimize through-film defects and improve stability with a simple, scalable deposition process.

A new class of layer-by-layer (LBL) nanocomposite films have emerged as a promising material for a wide range of applications; despite their relative impermeability against corrosion, nanocomposite films have not yet been thoroughly investigated for anti-corrosion applications. Sandia researchers have developed a high-performing barrier coating to protect surface materials from atmospheric and chemical corrosion. Compared to existing materials, this LBL nanocomposite film leverages polymer clay materials with superior corrosion protection and impermeability imparted by highly-organized platelet layers with a conformal nature. The coating's multi-step process minimizes through-film defects, improves stability, and allows the incorporation of electrically-insulating clay constituents. This coating presents an effective alternative to costlier, more toxic, and less scalable films for anti-corrosion protection.

Patent Pending
Technology Readiness Level: 3

ADVANTAGES

- Highly tunable properties
- Diverse surface materials
- Dip-coat or spray application
- Low thickness (nanometer to micrometer thick)
- Reduced manufacturing cost

APPLICATIONS

- Electronics/microelectronics
- Medical devices
- Structural materials
- Decorative

SENSING AND COMPUTING

Sensor technologies, which have grown out of Sandia's longstanding contributions to defense research, present a wealth of possibilities for industry applications including highly automated vehicles.

Microsystems, Engineering, Science, and Applications Complex

The MESA Complex integrates the numerous scientific disciplines necessary to produce functional, robust, integrated microsystems and represents the center of Sandia's investment in microsystems research, development, and prototyping activities. Its mission is to develop beyond leading edge trusted microsystem technologies to enable new and increasingly powerful macro-system capability and functionality for critical national security platforms.

National Security Photonics Center

Sandia serves the nation in developing and delivering leading-edge integrated photonics solutions for our customers and partners in the national security sector. Leveraging the broad capabilities within the MESA facility, the National Security Photonics Center's (NSPC) activities range from ground-breaking research through product delivery and qualification with a focus on high performance pathfinder solutions.

NANOANTENNA PHASED ARRAY AND TRANSCEIVER

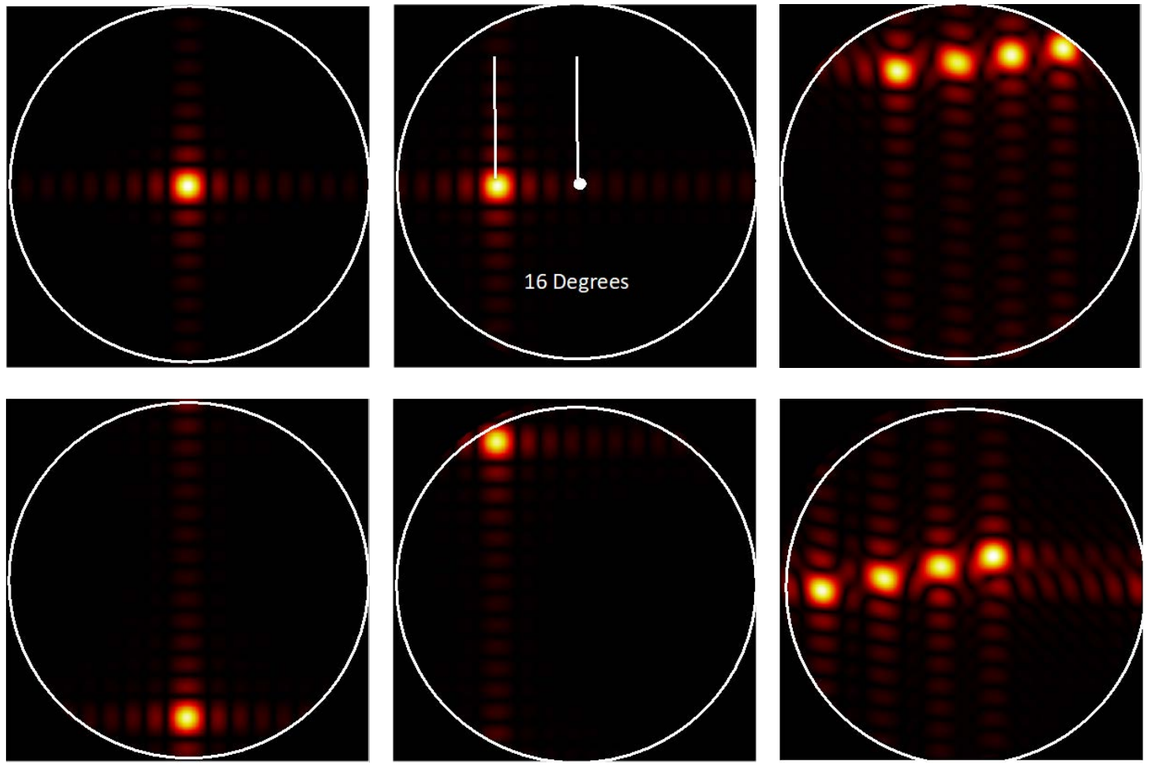
FOR WIDE-ANGLE OPTICAL BEAMSTEERING

A scalable, modular architecture and wide-angle array for non-mechanical beamsteering — the basis of chip-scale integrated LIDAR.

Integrated photonic LIDAR is a highly complex and challenging integrated photonic technology with potential to enable new capabilities in defense, national security, and commercial applications. Sandia researchers have developed a scalable, modular architecture and wide-angle array for nonmechanical electro-optic beam-steering, capable of supporting chip-scale, integrated LIDAR systems.

The device is based on subwavelength spaced metallic nanoantenna fed by Silicon (Si) waveguides. Integrated thermo-optic phase-shifters along the propagation direction allows for subwavelength spacing in the propagation direction, while integrated 2-pi phase shifters on each subwavelength fed waveguide row provide 2D large angle beam steering. This large area array technology is manufactured in a Si CMOS compatible process in which control electronics can be co-integrated, and our phased array technology can be used to form 2D beams with small angular beam size electronically steered over the entire hemisphere. The flexible design of the nanoantenna aperture array allows for tailoring angular beam size and side-lobe suppression which leads to low cross-talk. This technology leverages Sandia's silicon photonics platform, which encompasses core building blocks of many active and passive photonic devices.

US Patents 9, 104, 086 **and** 9,740,079
Technology Readiness Level: 4



ADVANTAGES

- Wide-angle optical beamsteering
- Non-mechanical design enhances reliability and reduces power
- Chipscale, simplified design
- Supports fixed wavelength operation
- Improved beam quality

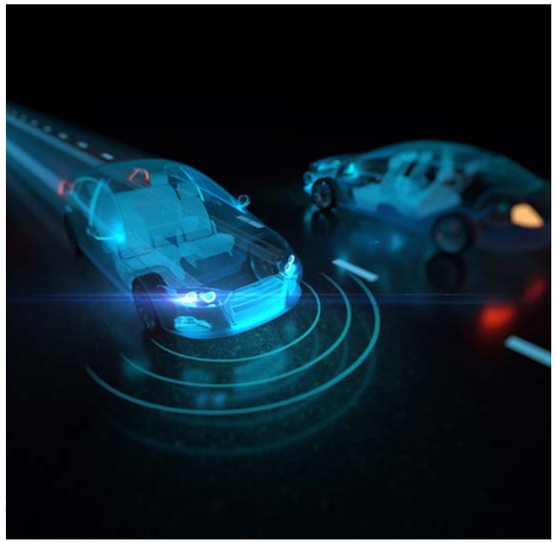
APPLICATIONS

- Automotive
- Aerospace
- Computing and electronics
- Defense
- LIDAR and GIS systems

SAGNAC OPTOMECHANICAL GYROSCOPE

A miniaturized gyroscope with improved sensitivity and performance for navigation applications requiring low-cost and reduced power devices.

Gyroscopes are important for applications in navigation, guidance, and control. Ideally, gyroscopes are accurate, stable, low cost, low power, and small weight and size, in some cases with high dynamic range. Many of these applications could benefit from miniaturization; however, the possibilities are limited because designs for conventional gyroscopes tend to exhibit better sensitivity and resolution at larger scales.



Optomechanical Gyroscope to sense rotation in applications that require high-performing, small form-factor devices for navigation, guidance, and control applications requiring low-cost and reduced power requirement devices. This gyroscope design solves a longstanding trade-off between size and performance by leveraging the scaling properties of the optomechanical spring effect, which improves scale factor sensitivity as device dimensions shrink. Upon rotation, the laser frequency detuning changes due to the Sagnac effect. The change in detuning induces a change in the mechanical resonant frequency due to the well-known optical spring effect. This gyroscope design may achieve sensitivity that competes with fiber-optic gyroscopes at an order of magnitude lower cost and size.

US Patent 10,458,795
Technology Readiness Level: 3

HORIZONTALLY POLARIZED DUAL BAND GPS ANTENNA

A mechanically robust, horizontally polarized dual band GPS antenna with improved performance in cluttered signal environments.

Sandia researchers have developed a mechanically robust, Horizontally Polarized Dual-Band GPS Antenna with improved performance in cluttered signal environments. This is achieved with an array design featuring several dipole antennas arranged in a circular pattern from a central plate with an electrical feed. The antenna's horizontal polarization mitigates coupling between itself and orthogonally polarized antennas in its environment. The dual band (L1 and L2) antenna has a wide field of view and is designed to survive high-shock and high-temperature environments. Its design provides additional benefits such as structural stability, thermal handling, and mitigation of electrostatic discharge. This device has the potential to vastly improve GPS reception and performance in harsh and varied environments.

US Patent 10,290,950
Technology Readiness Level: 9

ADVANTAGES

- Mitigates coupling with neighboring orthogonally polarized antennas
- Preserves pattern quality in cluttered environments and reduces interference
- Dual band (L1 and L2 GPS frequencies) with wide field of view
- Tunable features
- Robust antenna and feed design
- Mitigates electrostatic discharge (ESD)

APPLICATIONS

- Automotive
- Aerospace
- Communications
- Defense/security
- Extreme environments

FUEL CELLS, HYDROGEN STORAGE, AND SAFETY

Hydrogen and fuel cell technologies are critical for realizing a clean and secure energy future. Sandia provides deep quantitative understanding through research in hydrogen and fuel cell materials.

H-Mat and the Hydrogen Effects on Materials Laboratory

The Hydrogen-Materials Compatibility Consortium (H-Mat) is focused on how hydrogen affects polymers and metals used in diverse sectors, including fuel cell transportation and hydrogen infrastructure. Among Sandia's capabilities is the Hydrogen Effects on Materials Laboratory (HEML). Located in Livermore, California, the HEML is a state-of-the-art research facility that houses assets for evaluating materials performance in high-pressure gaseous hydrogen.

HyRAM: Hydrogen Risk Assessment Models

The development of science-based codes and standards that define the safe use of hydrogen is critical for its broader use and deployment. By leveraging staff expertise in system design, quantitative risk assessment, and hydrogen release behavior, Sandia has created HyRAM, software that integrates validated, state-of-the-art models with data to create a tool for assessing the safety of hydrogen infrastructure to inform codes and standards development.

HyMARC: Hydrogen Materials Advanced Research Consortium

Through an enduring multi-laboratory network, HyMARC, Sandia and its national lab partners use their unique capabilities and expertise in multiscale modeling, synthesis, and characterization to enable advances for hydrogen storage. Its mission is to accelerate discovery of materials that meet industry requirements for on-board vehicular hydrogen storage or that can be used as carriers to transport hydrogen over long distances.

HydroGEN-AWSM: Advanced Water-Splitting Materials for Hydrogen Production

Like HyMARC, HydroGEN is a multi-lab consortium organized to accelerate the development of materials and technologies for the clean, sustainable, and low-cost production of hydrogen. Sandia brings its core competency in solar thermochemistry to advance the use of solar heat to split water molecules and develops novel technology to generate hydrogen at large scale.

Sandia supports the U.S. Department of Energy's (DOE) H2@Scale initiative, which aims to advance hydrogen use for energy production and storage, as well as industrial processes.

POLYMER MEMBRANE SEPARATORS FOR FUEL CELLS

Versatile polymer membrane separator technologies with improved long-term stability, performance in high temperatures, and suitability for acidic and alkaline environments.

Fuel cells are hailed as clean, quiet, and efficient technologies with great promise for electric vehicle applications. To date, water-based acidic polymer electrolyte membrane fuel cells (PEMFCs) have been widely studied in vehicle applications, but due to their inability to perform in high temperature operation and use of platinum, a costly precious metal, PEMFCs face persistent limitations in cost and performance. Alternatively, alkaline membrane fuel cells (AMFCs) have garnered interest for fuel cell vehicles due to their ability to leverage inexpensive, nonprecious metal catalysts; however, their chemical stability under operating conditions still requires enhancement to compete with industry standard alternatives.

Sandia researchers have developed versatile membrane technologies with improved long-term stability and performance in high temperatures. With chemical optimization, these membranes, polymers, and ionomers are suitable for acidic or alkaline environments. These innovative materials are built upon an inexpensive poly(phenylene) backbone with ionic conductivities, chemical stabilities, and alkaline durability that are superior to commercially available AMFCs. Together, they present a more efficient, cheaper alternative to industry standard fuel cell membranes and have the potential to greatly reduce fuel cell manufacturing costs and performance.

US Patents 7,301,002; 7,816,482; 7,888,397; 8,110,636; 8,809,483; 9,534,097; 9,580,541; 10,053,535; 10,370,483

Technology Readiness Level: 2/3

GAS DIFFUSION ELECTRODES FOR FUEL CELLS

A gas diffusion electrode technique resulting in little to no leftover methanol, increasing overall fuel cell effectiveness and performance.

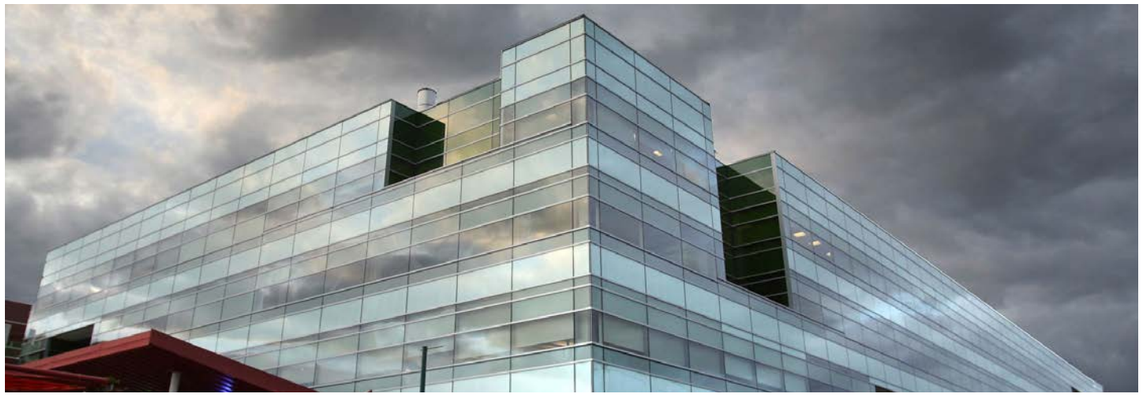
Direct methanol fuel cells have an advantage over hydrogen fuel cells because the liquid methanol has high energy density and is easily transportable. However, one of the challenges with this process has been the large amount of methanol that crosses over from the cathode side of the membrane electrode assembly. This crossover poisons the cathode, decreasing operating voltage and weakening the power output of the cell. Sandia researchers have developed a method for mitigating the methanol crossover poisoning effect in fuel cells. This unique Gas Diffusion Electrode Technique results in little to no leftover methanol, therefore increasing the overall effectiveness and performance of fuel cells.

US Patent 9,515,340

Technology Readiness Level: 4

BIOENERGY AND BIOFUELS

Harnessing the solar energy in biomass could transform our nation's transportation energy landscape, yet doing so requires further scientific breakthroughs and rapid commercialization. Sandia, in partnership with stakeholders, is beginning to research an adaptable framework that will develop biofuels for advanced engines.

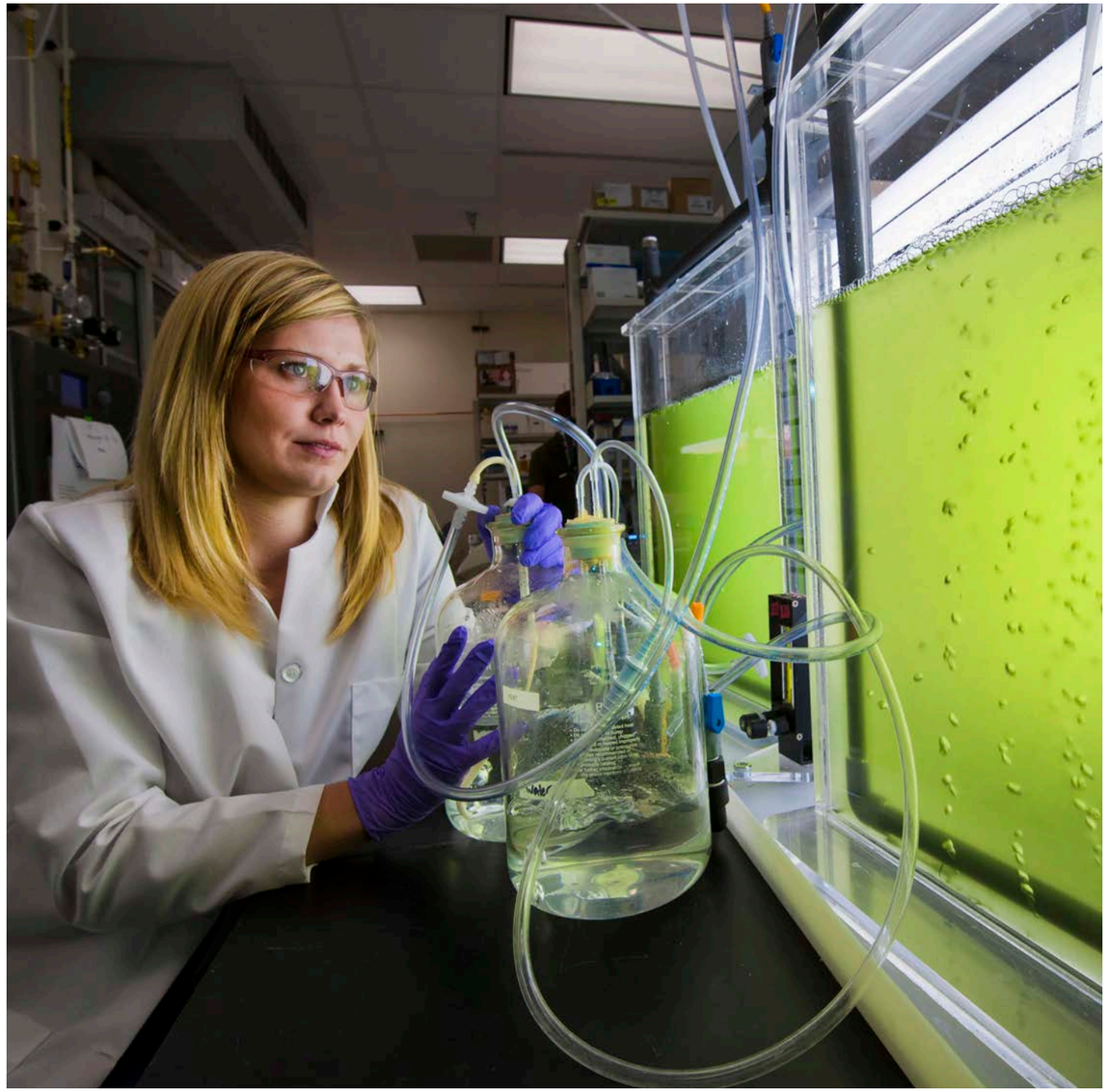


Joint BioEnergy Institute

The Joint BioEnergy Institute (JBEI) is a U.S. Department of Energy (DOE) bioenergy research center in Emeryville, California that is investigating the efficient conversion of lignocellulosic biomass in fuels. JBEI partners include Sandia, Brookhaven, Pacific Northwest National Laboratory, Iowa State University, the University of California (UC) campuses at Berkeley, San Diego, and Santa Barbara, and TeselaGen Biotechnology, Inc.

Co-Optimization of Fuels & Engines

Sandia participates in the U.S. Department of Energy's (DOE) Co-Optimization of Fuels & Engines (Co-Optima) initiative. Co-Optima leverages top scientists, engineers, and analysts from nine national laboratories and more than twenty university and industry partners across the country. Their focus is to investigate the dynamic design variables of fuels and engines to boost efficiency and performance while minimizing emissions in light-duty passenger cars to heavy-duty freight trucks.



TANDEM CONVERSION OF MIXED ALGAL BIOMASS

An integrated, high-efficiency conversion process for producing high purity biocrude oils, alcohols, and biofuels from wet algal biomass with minimal waste.

Algae represent a promising biomass crop for supplying renewable biofuels and useful industrial chemicals, however, the processing of algal biomass to produce pure, low nitrogen bio-oils is both highly energy intensive and produces significant waste. Given this, new industrial processes which reduce the energy use and/or minimize waste production are needed to make algal-derived fuels economically feasible and closer to realizing their potential as a renewable liquid fuel source.

To address this challenge, researchers at Sandia National Laboratories have developed a consolidated, high-efficiency process for producing biocrude oils, alcohols, and protein co-products from wet algal biomass. By leveraging **Tandem Biochemical and Thermochemical Processing Techniques**, researchers greatly reduced energy requirements compared to refining processes where algal biomass is dried prior to refinement. Specifically, a two-phase thermochemical pre-treatment step segregates fermentation-inactivating biomolecules, greatly increasing process efficiency. This process enables the utilization of all algal biochemical intermediates for a variety of chemical products, increasing process production value and reducing waste generation.

US Patent 10,077,454 with additional patents pending

Technology Readiness Level: 4

PARTNERING WITH SANDIA

Sandia can offer access to world-class scientific knowledge, advanced technologies, and specialized research facilities through a variety of partnership types.

License Agreements

Sandia can work with industry, government, other national laboratories, and academia to find the right license agreement to fit their needs.

Cooperative Research & Development Agreement

In a Cooperative Research and Development Agreement (CRADA), Sandia and one or more partners outside of the federal government can collaborate and share the results of a jointly conducted research and development project.

Strategic Partnership Projects or Non-Federal Entity Agreements

In a Strategic Partnership Project (SPP) or Non-Federal Entity (NFE) agreement, Sandia can perform work on a reimbursable basis for a non-federal entity from private industry, state/local government, nonprofits, or academia.

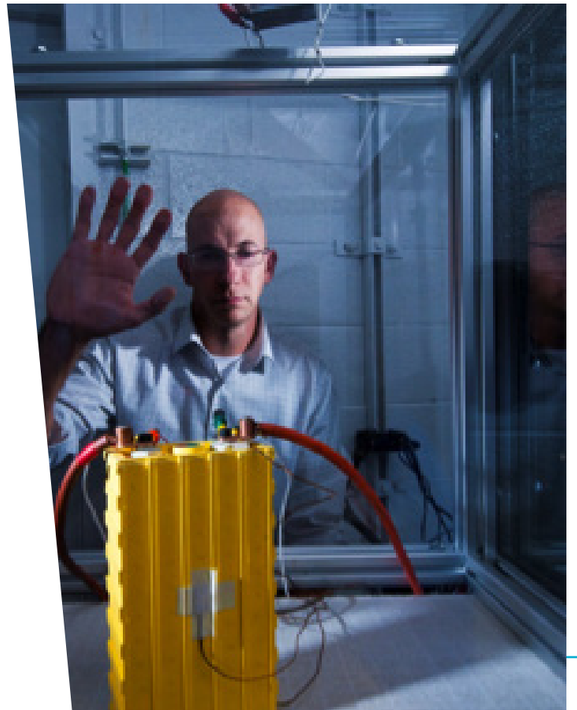
New Mexico Small Business Assistance Program

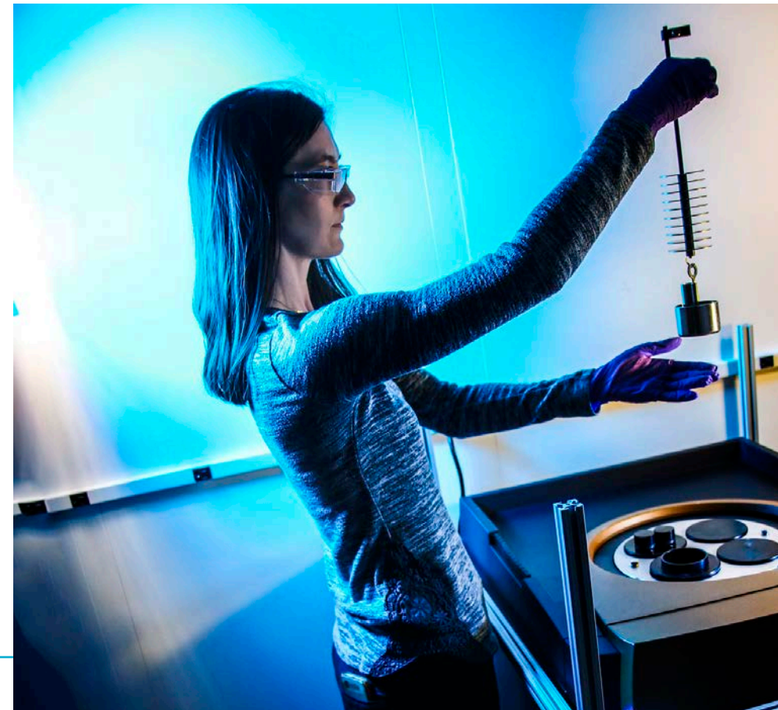
The New Mexico Small Business Agreement (NMSBA) Program allows New Mexico small businesses facing a technical challenge to access the unique expertise and capabilities of Sandia.

Technology Deployment Center (TDC) Agreements

Technology deployment centers are a unique set of scientific research capabilities and resources. The primary function of technology deployment centers is to satisfy DOE programmatic needs, while remaining accessible to outside users.

With a history of technology transfer success, Sandia's collaborations with diverse partners bring new technologies to the marketplace and contribute to the economic well-being of the nation.





CONTACT US!

Send inquiries to ***ip@sandia.gov***

Visit our website at ***ip.sandia.gov***

Intellectual Property Management & Licensing

Sandia National Laboratories
P.O. Box 5800
Mail Stop 0114
Albuquerque, NM 87185-0114

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